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ONTARIO DEPARTMENT OF EDUCATION

CIRCULAR G-S.17B.

CURRICULUM STUDY GUIDE FOR GRADE 13 BIOLOGY

1965

ISSUED BY AUTHORITY OF THE MINISTER OF EDUCATION

PART A /GENERAL OUTLINE

The advances that have taken place during the last decade in the biological sciences are having a quiet but ever-increasing impact on society. The consequences of these advances, however, will produce changes in life as we know it, of a magnitude that previously would have been considered as science fiction.

A formal education received a generation ago leaves the owner out of step with biology unless he has kept pace with the trends and new information. Publishers in the field of biology find that information can become outdated between the onset of writing and the time of publication. One can no longer master the contents of a single textbook and lean back for very long with a feeling of comfort. Instead, it is necessary to examine many books and to be aware of the ever-increasing number of publications. The biology teacher must be prepared both to keep himself abreast of new information and to guide his students through basic principles and changing concepts.

Since teachers and students are faced with an ever-changing array of information in science, a course of study must be a flexible guide of a temporary nature, and not an academic strait-jacket that is adjusted each decade.

The new course in Biology, *Curriculum S.17B,* has been designed to allow for maximum flexibility and necessary adjustment and refinement. Flexibility, which must be a prime requisite of any new Biology course, can be disconcerting to teachers who must work within rigid time schedules and meet examination deadlines.

As stated in the preamble of *Curriculum S.17B,* the two main objectives of the course are: (1) to provide some general knowledge for those who will not study this subject further, and (2) to provide a good foundation for those who will proceed to advanced work. To achieve these two objectives, flexibility is imperative. For those students terminating their formal study of the subject, a satisfying, carefully synthesized course must be administered, and for those students proceeding to advanced work, the course must be a bridgehead from which each student can advance in any desired direction.

Until the time that courses are devised for the two types of students, we must be aware of the duality of the present course. Textbooks must of necessity capture the spirit of the course, and make information available to satisfy the needs of either type of student. Students in turn must become selective in their choice of materials to avoid becoming victims of factual indigestion. Fundamental principles and relevant facts must be carefully selected from the inexhaustible sources of information. The construction of students' notes can no longer be a routine paraphrasing of a single textbook, but rather a discriminating organization of information relevant to the principle under investigation. A teacher can be invaluable in helping students to organize their system of note-making at the onset of the course.

In conjunction with their note-making, students must have ample opportunity to observe the various slides, specimens, and dissections, and to interpret what they see by simple but original diagrams.

Electron photomicrographs are sometimes difficult to interpret so that diagrams have significant value. The diagrams should be original, and drawn after the student has had the opportunity to examine as many photomicrographs of the same structures as conveniently possible. A variety of reference books and periodicals should be available to enable the student to research the material needed.

Before examining specifics in the course, one should look at its general structure. To do so, one should recall that the former Botany and Zoology courses were separate entities. A student taking both

courses was rarely able to produce sufficient carry-over to bridge the gap between the two and appreciate the "oneness" of life. Each course was a study of several organisms, studied separately, and had a nebulous synthesis superimposed by the fact that each subsequent organism studied was higher in the evolutionary scale. The new course stresses the characteristics of all living things and specific organisms serve as illustrative examples.

The course is divided into seven units of varying length. The first unit is a short one of five periods that serves as an introduction for the rest of the course. Unit IV, the classification of organisms, is a discreet unit that could be taught at any time in the course. Topics 3, 4, and 5 have been deleted to shorten this unit to about eight periods. Originally the entire unit would have required 18.

Unit 1	Characteristics of Living Things	5 periods
Unit 2	Cells	35 "
Unit 3	Organisms	55 "
Unit 4	Classification of Organisms	8 "
Unit 5	Interdependence of Organisms	12 "
Unit 6	Reproduction of Plants and Animals	10 "
Unit 7	Heredity, Environment and Evolution	15 "
		140 "

When confronted with a new course, it is a natural reaction for us to question how to approach those parts of the course that are strikingly different from what we have grown accustomed to. Here are a few of the questions that may be asked:

(1) How can the course be completed in 140 periods?
(2) What depth of treatment is required?
(3) What should be done with the organic chemistry involved?
(4) What type of examination can be expected?
(5) How much experimental work should be done?

Questions 1 and 2 should not pose a problem, because question 1 answers question 2. The depth of treatment is indicated by the period allotment. For a school that has few unnecessary disruptions, five periods a week for 28 weeks is adequate for teaching the course. The second unit of 35 periods will necessitate careful planning because it is the unit with more new material than the others. Lack of familiarity with the subject matter may result in a superficial skimming of the surface. It is not sufficient to have students learn by rote the structure and functions of cell parts. The depth of treatment of the rest of the course should prove less difficult, since a great deal of the subject matter is more familiar.

The organic chemistry need cause no alarm unless one tries to master all the great wealth of material found in textbooks. The course states three times that formulae are not required for examination purposes. One has two alternatives then in teaching the parts of the course involving chemistry. One may use formulae and chemical equations in explaining concepts, or one can rely on names, word equations, and descriptive words to portray the same information. Which alternative to use is a matter of choice. If all or most of the students are taking chemistry as well as biology, it is obvious that using formulae would be an advantage. One can argue of course that the organic chemistry in Grade 13 comes at the end of the course and that it does not cover some of the concepts required in the Biology course. Some teachers have solved this problem by teaching the organic chemistry first. Others have gone beyond the call of duty and given extra classes on organic chemistry to non-chemistry students. Whether or not most of your biology students take chemistry, and whether most of your students are going to continue the study of biology at university, should dictate to you whether you use formulae or not. The flexibility of the course allows for definite choice in this area.

The next question naturally follows: What type of examinations can be expected? There is nothing in the course to suggest an unusual type of examination. Of necessity the flexibility of the course should be reflected in an examination. If one has the choice of teaching the organic chemistry with or without the use of formulae, it is obvious that either approach should be granted equal merit on an examination. The subject matter of the course lends itself to the use of objective questions and essay questions just as much as the previous Botany and Zoology courses.

The fifth question, dealing with how much experimentation should be carried out, has the same answer as any course in science. If any part of any science course can best be handled by experimentation, then that should be the procedure used. Experiments must be considered as teaching expedients rather than testing devices. A few experiments are formally required in this course, and these could be considered as testing devices also.

In analysing any particular part of the course to determine the depth of treatment, one obviously starts with the period allowance for a unit. As an illustration, Unit II is allowed 35 periods. Although there are seven topics in Unit II, some will require more or less than five periods each. Topic 4 would require more than five periods, whereas Topic 6 may require less.

To continue the examination of Topic 4, let us look

at 4(b). Here is an example involving information that is relatively new at the secondary school level. Formerly it was sufficient to realize that respiration is the liberation of energy from assimilated food to enable an organism to carry out its functions. In addition, glucose is oxidized to produce this energy requirement. This snippet of information, accompanied by a word or chemical equation, was sufficient depth of treatment.

Since so much is understood about the process of respiration today, it is insufficient to expose a Grade 13 student to the unsophisticated approach that may be used at a junior level. However, we must be careful not to subject the Grade 13 student to the sophisticated level that is expected at university. Not that the student is unable to cope with a university approach, but rather because the present system in secondary schools does not allow the time and freedom required for a treatment in that depth.

PART B/UNIT PRESENTATION

With a great wealth of information concerning respiration at our disposal, we must be careful not to inundate the basic principles involved by a memorization of meaningless chemical terminology. Following is one possible way of handling the information concerning respiration:

Energy Transfer Via ADP-ATP System

1. Respiration is the liberation of energy from energy-rich compounds to forms useful to the organism.
2. Bond energy may be high or low.
3. Energy required by the organism is involved in the formation or destruction of chemical bonds.
4. To perform work, the cell must transfer potential energy from one compound to another.
5. To facilitate the transfer of potential energy with minimal loss, intermediary compounds are necessary to acquire bond energy from one molecule and transfer it to another.
6. ADP and ATP are two intermediaries formed by ester linkages of phosphoric acid to a nucleotide.
7. ADP and ATP differ only in the amount of phosphorylation, that is the number of phosphate groups involved. ADP – adenosine *di*phosphate, has two such linkages, whereas ATP – adenosine *tri*phosphate, has three.
8. The ability of ATP to transfer phosphate groups along with the energy of high-energy bonds to other compounds, makes it a most important chemical in a cell.
9. The amount of ATP in a cell is minute, since ADP is reconstituted into more ATP.
10. More energy is made available to the cell by collective small increments from ATP, than from the oxidation of glucose directly.
11. The breakdown of glucose involves three stages in the respiratory cycle: glycolysis, formation of acetyl-coenzyme A, and the Krebs cycle. Glycolysis refers to the anaerobic degradation of carbohydrates in living cells. The other two stages in the cycle are aerobic.

Glycolysis

1. Glucose must enter the respiratory cycle as a phosphate ester, so it is phosphorylated.
2. The 6-carbon molecule is "primed" to be split into 3-carbon molecules by undergoing internal structural changes.
3. The 6-carbon molecule is fragmented into two 3-carbon molecules.
4. The 3-carbon fragments are phosphorylated and then dehydrogenated (this may be termed oxidation, since electrons are lost).
5. One phosphoric acid residue is removed from each 3-carbon unit to release enough energy and phosphate to produce one molecule of ATP from one of ADP.
6. Re-arrangement of the molecule takes place, with the resultant loss of a molecule of water.
7. Phosphate is then removed from the re-arranged molecule. This provides energy and phosphate to form one ATP molecule from one ADP molecule. The 3-carbon unit is now pyruvate.

Formation of Acetyl-coenzyme A

The 3-carbon pyruvate molecule is dehydrogenated, and at the same time loses one carbon as a CO_2 unit is removed. The 2-carbon fragment is combined with coenzyme A to form acetyl-coenzyme A (the acetyl part referring to the 2-carbon fragment).

Krebs Cycle or Citric Acid Cycle

1. The acetyl fragment of acetyl-coenzyme A unites with oxaloacetic acid to form citric acid.
2. The acetyl fragment of the citric acid molecule is then oxidized to carbon dioxide and water, and oxaloacetic acid is regenerated.
3. The acid is free to unite with another acetyl fragment and thus complete the cycle.
4. During the cycle, 12 molecules of ATP are formed for each acetyl fragment that is oxidized.

The entire oxidation of glucose may be understood

if the sequence of events is understood, and the reason why these events take place in terms of energy production. The concepts of oxidative phosphorylation, dehydrogenation, decarboxylation, the electron transport chain, and the use of enzymes should be emphasized, rather than the memorization of countless chemical names and formulae. Alternatively, the oxidation of glucose may be handled completely by chemical formulae and equations or by graphic charts. Grade 13 students at present do not possess enough knowledge of organic chemistry to enable an easy handling of the information in this manner.

In summary we may draw the following conclusions:

1. The depth of treatment is directly dependent on the allowance of five periods a week.
2. The course may be taught with minimal emphasis on formulae and chemical equations, but with an emphasis on the complete understanding of the reactions that take place and the reasons why they occur.
3. The course is intentionally flexible to allow for a terminal treatment of biology or for an introduction to university biology.
4. Students and teachers must become selective in drawing material from textbooks and reference books.
5. An examination set on this course must of necessity reflect the flexibility of the course and not act as a restrictive factor in studying biology.